CYCLE DE CONFÉRENCES

Séminaire général de physique de l'Institut Polytechnique de Paris
Département de physique de l'École polytechnique

DOES THE SPIN HAVE A MASS ?

by Jean-Eric Wegrowe

Professor at Ecole Polytechnique, Irradiated Solids Laboratory

THURSDAY JANUARY 22, 2026

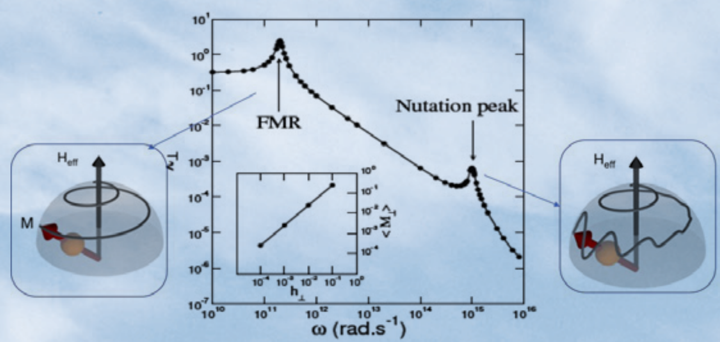
5 pm - 6:15 pm
LECTURE HALL PIERRE FAURRE
ÉCOLE POLYTECHNIQUE

This curious question about the mass of the spin lies at the heart of recent advances in magnetization dynamics and motivates this overview about *magnetization nutation*—a phenomenon that has only recently been brought into clear experimental focus.

In conventional spin dynamics, a magnetization vector subjected to a non-collinear magnetic field undergoes Larmor precession at a frequency imposed by the gyromagnetic ratio (~27 GHz/T). This motion, damped by environmental coupling and described by the Landau–Lifshitz–Gilbert equation (first-order time derivative of the magnetization), has long been considered the complete picture. However, this picture turns out to be *incomplete*. The reason why it is incomplete can be understood with using basic physical arguments, that are well-known in various branches of physics (divergence of the total power, analogy with the spinning top, dichotomy between fast and slow degrees of freedom, limit of validity of the Ampere's magnetic dipole model, etc).

We proposed some years ago that if magnetization carries inertia—raising the question of an effective "spin mass"—its dynamics should include nutation: ultrafast oscillations superimposed on precession, analogous to the wobbling of a spinning top and expected to occur at terahertz frequencies.

Recent experiments, supported by a wide range of independent theoretical approaches, now provide compelling evidence for this additional dynamical degrees of freedom. This talk reviews the development of the idea of magnetization nutation, examines its physical origin, and discusses current perspectives and open questions on the inertial nature of spin dynamics.



Calculated ferromagnetic resonance and nutation resonance plotted as a function of the frequency of the excitation magnetic field. The pictures sketched the relaxation of the magnetization as a function of time (trajectory in the configuration space), for zero excitation magnetic field. Left: standard precession, right: precession with nutation.

J.-E. Wegrowe et al., *Magnetization dynamics, gyromagnetic relation, and inertial effects*, Am. J. Phys. **80**, 607 (2012), Kumar Neeraj et al. Inertial spin dynamics in ferromagnets, Nat. Phys. **17**, 245–250 (2021), Ritwik Mondal et al *Relativistic theory of magnetic inertia in ultrafast spin dynamics, Phys.* Rev; B **96**, 024425 (2017), Anulekha De et al. *Magnetic Nutation: Transient separation of magnetization from its angular momentum*, Phys. Rev. B **111**, 014432 (2025).

https://portail.polytechnique.edu/physique/fr/seminaire-de-physique